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Interpenetrated polymer networks based on commercial silicone elastomers and ionic networks with high dielectric permittivity and self-healing properties

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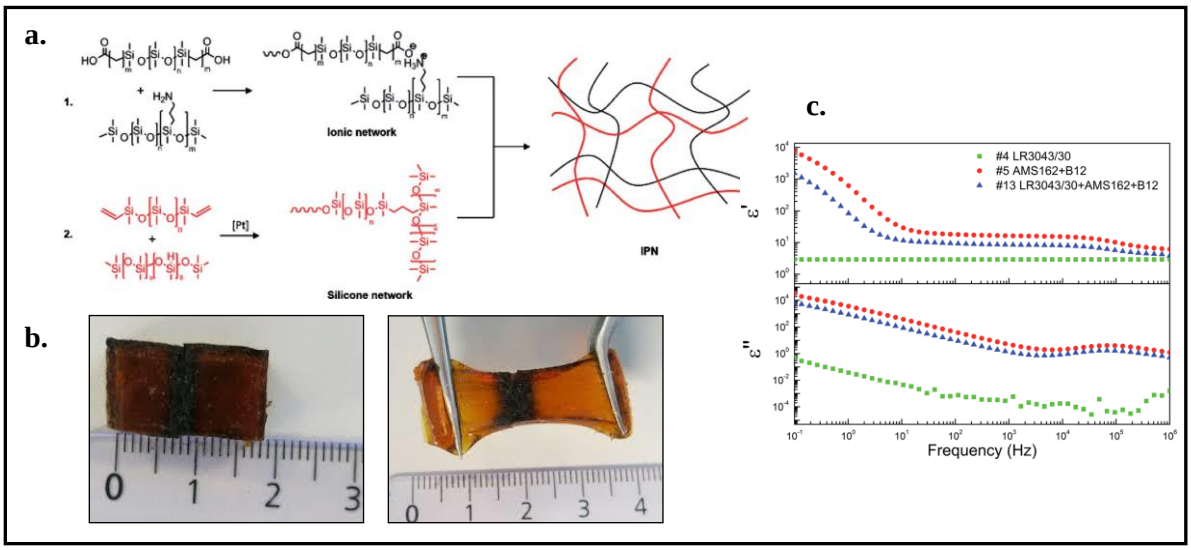
The dielectric elastomers (DEs) technology can be used in many advanced applications, such as actuators, generators and sensors, showing advantageous and promising properties[1]. However, the main disadvantage is the high driving voltage required for the actuation process which limits the applicability. One method used to avoid this limitation is to increase the dielectric permittivity of the material in order to improve the actuation response at a given field. Recently, interpenetrating polymer networks (IPNs) based on covalently cross-linked commercial silicone elastomers and ionic networks from amino- and carboxylic acid- functional silicones have been designed[2] (Figure 1). This novel system provides both the mechanical stability and the high breakdown strength given by the silicone part of the IPNs and the high permittivity and the softening effect of the ionic network. Thus these improved properties are achieved without consequently increased Young's moduli and decreased breakdown strength compared, for example, with other silicone elastomers containing fillers. In particular, the interpenetrating systems show dielectric permittivity ε' from 6,7 to 2 x 10^3 at low frequencies (0,1 Hz), and the commercial elastomers RT625 and LR3043/30 provide the best viscoelastic properties to the systems, since they maintain low viscous losses upon addition of ionic network. The values of the breakdown strength in all cases remain higher than that of the reference pure PDMS network (ranging from 45 V/µm to 90 V/µm)[3]. In addition, the ionic part of the interpenetrating systems, based on non-covalent interactions, provides promising self-healing properties both upon mechanical rupture and upon electrical breakdown. The systems are capable of recovering and to support more than 100% elongation of the reassembled samples (Figure 2). This additional advantage achieved by the IPNs represents an encouraging step forward in the challenge of increasing the life-time of the DEs.



a. Reaction scheme for the sequential formation of ionic and silicone IPNs[2].
b. Self-healing properties of the IPNs (dark areas are from the cutting line)[3].
c. Dielectric permittivity ε'and dielectric loss ε" vs frequency for LR3043/30 (#4), a pure ionic network (#5) and a IPN (#13)[2].

References

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